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INTERNATIONAL ISSUE

telephony

DECEMBER 21, 1981

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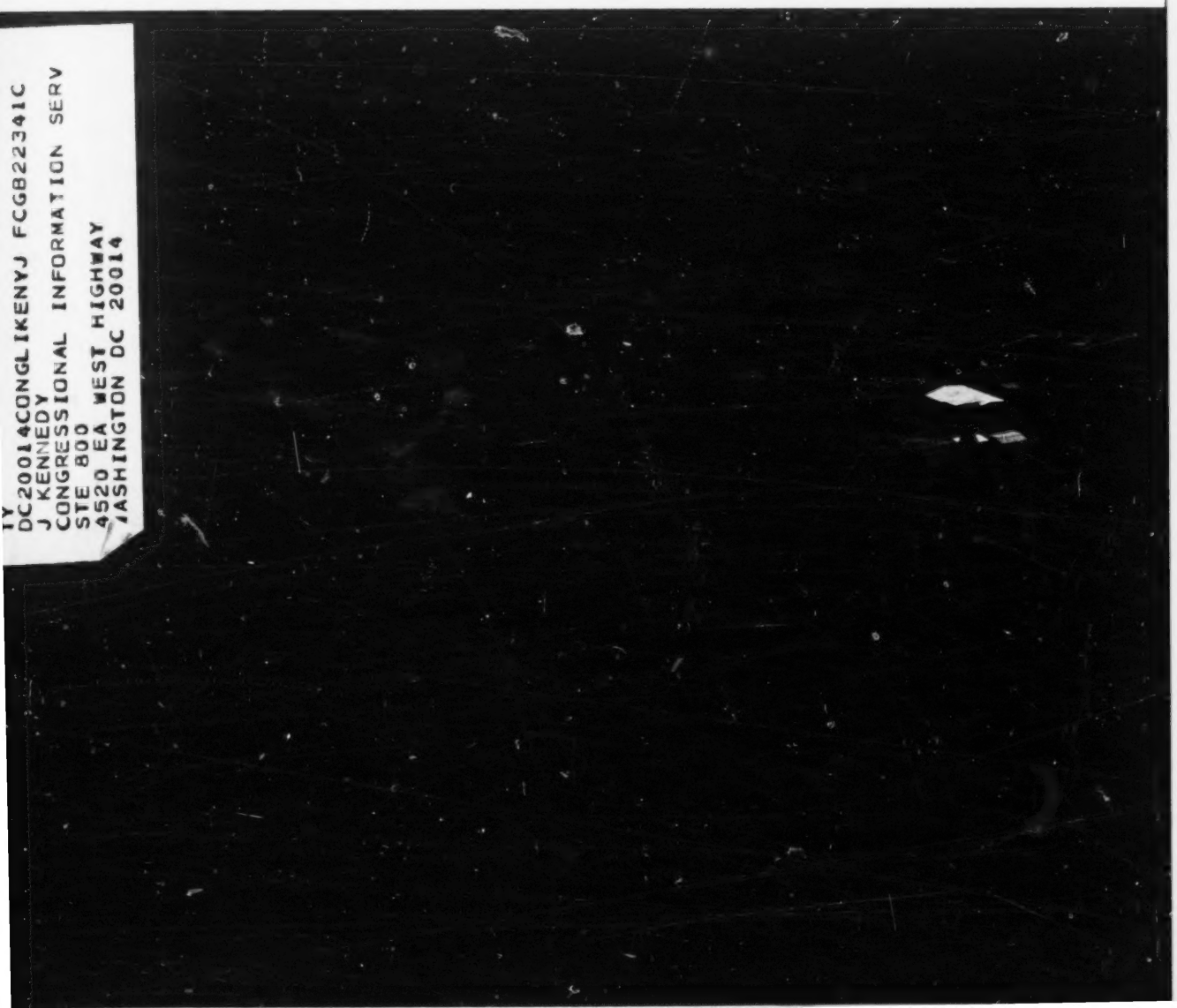

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Power for remote telecom sites may be blowin' in the wind

In some remote areas not served by public electric utilities, wind power is a promising energy source. Here's one way to harness its potential

DONALD J. MAYER

THE USE OF THE POWER in the wind as an energy source is hardly a new technological breakthrough.

As early as 2800 B.C., the Egyptians used sails to assist the rowing power of slaves. The Persians used vertical axis windmills to grind grain in the seventh century A.D.

The Crusades brought that technology to Europe. The Dutch developed the horizontal axis propeller-type windmill that Don Quixote battled in his dreams. It was an American innovation in the early 19th century that resulted in the common American water-pumping windmill or prairie fan. At the turn of the century, electricity was produced by windmills in America and Denmark. By 1930 more than 12 manufacturers in the United States alone were producing "windchargers" (now called small wind energy conversion systems or SWECS) for farmers in the Plains States. For many American farmers, the first experience with electricity was from a windcharger used to charge batteries to power a radio.

These small wind machines were sold by retailers as a package consisting of a radio, battery and roof mounted windcharger. This marks the start of the use of wind energy as a power source for telecommunications applications.

The vibrant wind industry of the 1930s and '40s saw the development of larger wind electric systems culminating in the 1250 kilowatt (kw) giant Smith-Putnam machine on Grandpa's Knob near Rutland, Vt., which produced electricity for Vermont during World War II. However, also during this time the Rural Electrification Act was passed, bringing government subsidized power to remote farms and homesteads, and forcing the wind industry into a period of hibernation.

DONALD J. MAYER is Vice President of North Wind Power Co., Inc., Waitsfield, Vt.

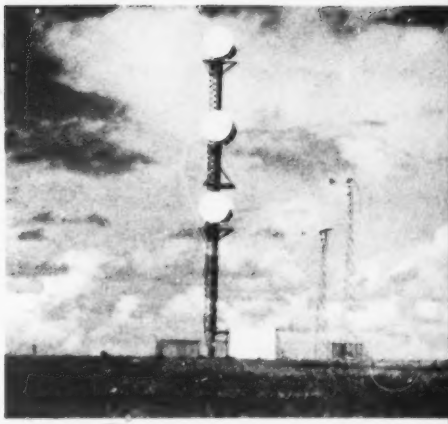


PHOTO shows two HR2 systems at the MCI microwave site in Kenna, N.M.

The competition from cheap government subsidized electrical power forced many manufacturers out of business and others moved into other areas. Some wind system manufacturers, however, began to seek new markets for their products. They found them in the remote power market for cathodic protection of pipelines, navigational aides and remote communications installations. These new cost-effective applications were not enough, however, to support the industry, and during the 1950 to 1970 period most manufacturers folded. The reawakening of energy consciousness sparked by the oil embargo of 1973 and the rapid escalation of fuel costs has sparked new interest in wind energy and a rebirth of the wind industry.

Finding a dependable source of electric power for remote microwave relay stations is a familiar and difficult problem for the communications engineer. Due to the nature of ultra-short electromagnetic waves, relay stations must be situated in mutual optical view and must be at a maximum vertical elevation. The best sites for microwave links almost necessarily have the disadvantage of limited accessibility and, in many cases, the cost of extending commercial power to such sites is prohibitive. The transportation and storage of fuel becomes a major factor in the cost of supplying independent power to such stations.

The rapid expansion of the worldwide telecommunications network and escalating fuel and transportation costs have caused communication planners to look at wind energy as an answer to the power problem.

The major deterrent to widespread

Table 1

Performance and environmental design criteria

Reliability:	The mean time between failures for the system shall be not less than 10 years.
Maintainability:	One maintenance day per year maximum.
Durability and life:	Machine shall operate continuously in extreme conditions and have a 25-year life.
Cut-in windspeed:	Minimize with regard to power production and system cost.
Cut-out windspeed:	Maximize with regard to power production and system cost.
Survival windspeed:	54 miles per second (120 miles per hour) minimum for steady winds; gusting to 75 miles per second (165 miles per hour)
Temperature:	−60°c to +60°c; (−76°F to +140°F).
Rain:	Torrential downpour accompanied by winds.
Snow, sleet, ice:	Ice buildup to 60 millimeters (2.5 in.) on all surfaces.
Hail:	Impact by hail up to 40 millimeters (1.5 in.) diameter.
Salt water spray:	Heavy ocean spray.
Dust:	Fine sand and dust accompanied by winds gusting to 45 miles per second (100 miles per hour).

usage of wind has been that little hardware was available; much of what was available was prone to failure and not designed to operate unattended in difficult environments.

This need for reliable wind systems for remote power was recognized by the U.S. Dept. of Energy (DOE). In 1977 DOE issued a request for proposals to develop a high reliability SWECS capable of supplying power in remote sites and harsh environments. Table 1 indicates the DOE design criteria for this wind machine.

North Wind Power Company, Inc., Waitsfield, Vt., responded to the DOE request and received a 2 year contract to design, develop and test a high reliability wind machine for remote applications.

The company's approach was to achieve reliability by limiting the number of moving parts and by using sophisticated aerodynamic and structural analysis to design a SWECS capable of meeting the government's stringent reliability criteria. The result of that effort was the HR2 wind electric system (Figure 1).

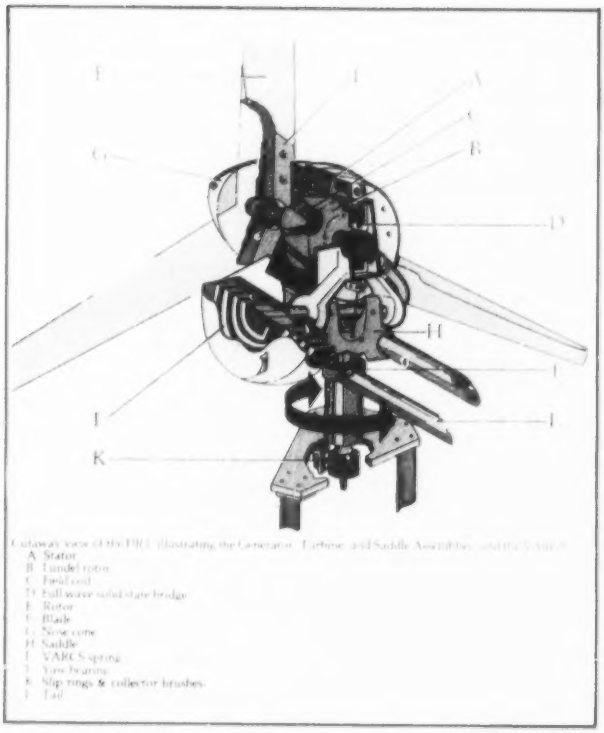
The system was a three bladed rotor directly connected to a specifically designed slow speed alternator. A unique mechanism called the VARCS (Variable Axis Rotor Control System) permits the rotor/generator to tilt back in winds over 20 miles per hour (mph). The VARCS combines in itself the critical functions of overspeed control, high wind shutdown and reset and manual shutdown for maintenance (Figure 2).

Since its introduction in 1979, the wind system has been used in remote applications ranging from cathodic protection of a buried pipeline on the Gulf of Mexico for Harco Corp., Houston, Texas, and the Houston (Texas) Natural Gas Pipeline Co., to powering remote telecommunications and telemetry in the Canadian Rockies. The system also is undergoing long-term testing by DOE in Colorado, by the U.S. Army in Arizona, by the Canadian Coast Guard in New Brunswick and in the Mexican national telephone system.

Of special interest to the telecommunications industry is the system's favorable economics for remote sites, particularly mountain top repeater sites which generally have adequate wind resources.

In typical installation at a remote repeater site, the wind system is mounted on an appropriately sized mast (20 ft. above any obstructions within 500 ft.) and is used to charge batteries to power the radio equipment. A voltage regulator protects the battery from overcharge and an auxiliary engine, thermo-

FIG. 1 *Cutaway view of the HR2, a wind power system.*



electric or turbine generator can be installed to provide power for extended windless periods and to provide redundancy for increased reliability. A recent project with MCI Communications Corp., Washington, D.C., in Kenna, N.M., was a special application, retrofit-

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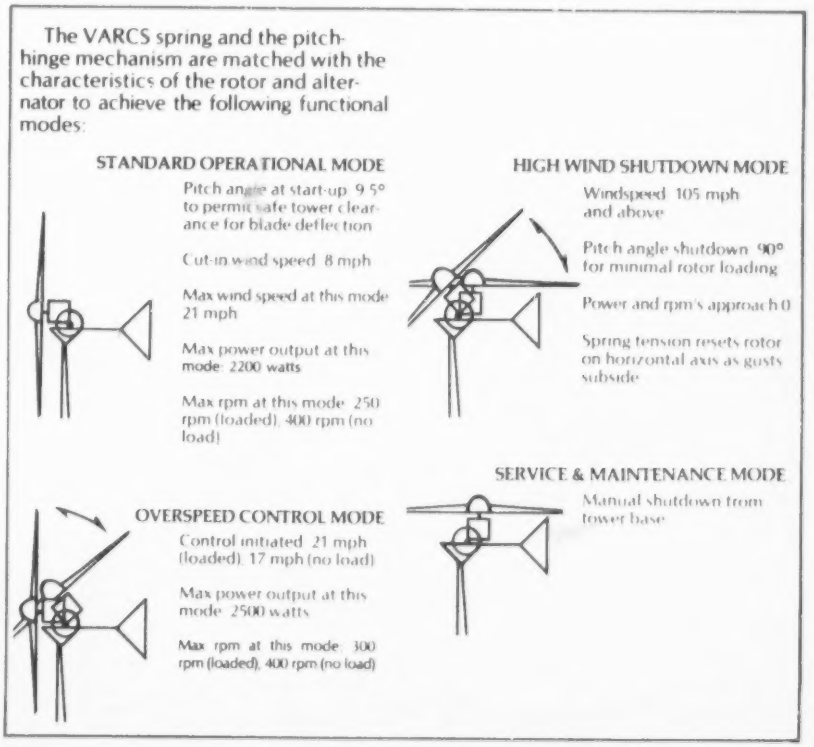
The VARCS spring and the pitch-hinge mechanism are matched with the characteristics of the rotor and alternator to achieve the following functional modes:
STANDARD OPERATIONAL MODE
Pitch angle at start-up 9.5° to permit safe tower clearance for blade deflection
Cut-in wind speed 8 mph
Max wind speed at this mode 21 mph
Max power output at this mode 2200 watts
Max rpm at this mode 250 rpm (loaded), 400 rpm (no load)
HIGH WIND SHUTDOWN MODE
Windspeed 105 mph and above
Pitch angle shutdown 90° for minimal rotor loading
Power and rpm's approach 0
Spring tension resets rotor on horizontal axis as gusts subside
SERVICE & MAINTENANCE MODE
Manual shutdown from tower base
OVERSPEED CONTROL MODE
Control initiated 21 mph (loaded), 17 mph (no load)
Max power output at this mode 2500 watts
Max rpm at this mode 300 rpm (loaded), 400 rpm (no load)

FIG. 2 *The functional modes which can be achieved by the VARCS spring and pitch-hinge mechanism.*

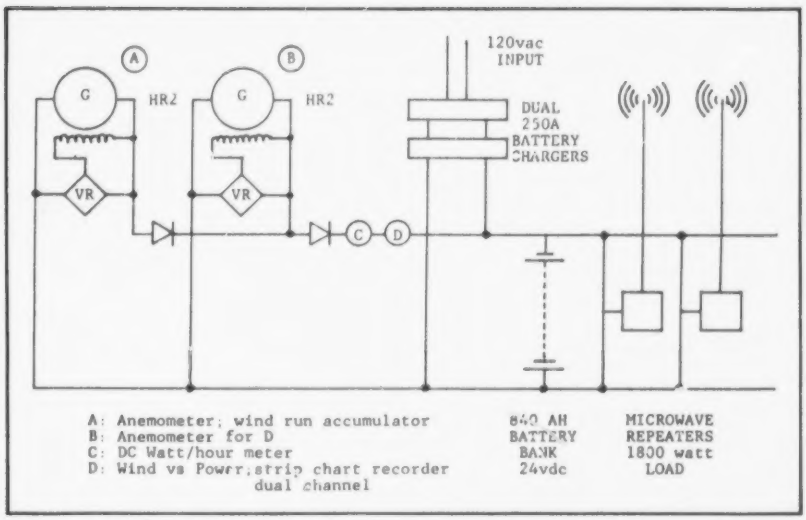

FIG. 3 *Schematic diagram of the hybrid power system at the MCI microwave repeater site in Kenna, N.M.*

ting the HR2 system at an ordinary microwave repeater site. MCI has many repeater sites, most of which are powered by the commercial utility grid. The Kenna site is a link in the Dallas, Texas, to Los Angeles, Calif., system and the continuous load at the site is typical—1.8 kw at 24 vdc (volts, direct current) nominal. This site is connected to the utility grid system and employs two 6 kw battery chargers to support the load and maintain an 840 amp per hour capacity battery bank. Two wind power systems were added to provide back-up power to extend the off-grid operating capability of the site without installing additional battery capacity or a diesel and related support equipment. Western Texas and eastern New Mexico are subject to severe winter ice storms; consequently, utility outages may exceed 48 hours. This area also has a significant wind resource with annual averages of 12 to 15 mph.

Initial power calculations indicated that the wind power system would permit the site to operate indefinitely without utility back-up from October through May. In the worst case summer months, the system can provide an average additional 5 days of operation when utility power is unavailable. Due to leasehold constraints, both units had to be placed within a 60 ft. square which includes the microwave tower and the shelter. With this constraint, good wind turbine siting practice dictated that the centers of the rotors be placed at different heights from each other and from the dishes themselves. A site plan was developed which placed one unit in the southwest corner on a 40 ft. Rohn self supporting tower, manufactured by Unarco-Rohn, Peoria, Ill. The first microwave dish is at 50 ft. The second unit was placed in the southeast corner on a 60 ft. self supporting tower. This layout places the 40 ft. tower upwind of the 60 ft. unit in the prevailing southwesterly winds and both machines upwind of the microwave tower.

The data taken thus far at Kenna have confirmed many of the performance parameters of the individual units and the total system. The power system uses the logic of the voltage regulators in the bat-

Continued on page 30

Table 2

Energy cost comparison of remote power systems (400 watt continuous load)

	Wind	Thermo-electricity	Gas turbine	Solar	Diesel
Capital costs					
General equipment	9800	15,920	18,854	55,000	5560
Site equipment fuel tanks, installation, tower or battery housing	10,000	10,000	10,000	10,000	10,000
Battery storage	6000	1500	1500	6000	1500
Installed cost	25,800	27,420	30,354	71,000	17,060
Operating costs					
Annual maintenance	500	750	1000	500	2000
Fuel (at about $2.00/gallon)	00	8760	5464	00	4029
10 year annual operating and maintenance	5000	95,100	64,640	5000	60,290
10 year life cycle cost	30,800	122,520	94,994	76,000	77,350
10 year kilowatt hour production	35,040	35,040	35,040	35,040	35,040
Cost per kilowatt hour	0.88	3.50	2.71	2.16	2.20

tery chargers and in the wind systems to shift the load from one power source to another (Figure 3). The battery chargers are set-up in parallel for float service at 2.2 vpc (volts per call) for a dc bus voltage of 26.5 vdc. The HR2 regulator is set at 27 vdc to limit the battery state of charge to 2.25 vpc. This arrangement limits the voltage window of the wind power system to 0.5 volts (26.5 vdc to 27 vdc). While this severely limits the total useful energy output of the wind system, it does permit some energy capture in normal operation while preserving the life of the float service batteries which were already in place at Kenna. In a new power system, deep discharge batteries would be specified for a wider voltage window and greater energy capture.

In a low wind condition, the battery chargers are on and supporting the load while maintaining the battery bank on float service at 26.5 vdc. As the wind speed increases, the terminal voltages of wind units reach that voltage and exceed it. At this point, in a 19 mph wind, the battery chargers cut-out and the wind units pick-up the load and begin to charge the batteries. When the bus voltage reaches 27, the regulator tapers back the generator field current to maintain that voltage. The load is now supported and the batteries are floated at this higher voltage by the wind power system. As the wind dies, the output voltage sags and the battery chargers cut-in again.

Given adequate wind resource, wind generated electrical power is the most cost effective means of providing power to remote non-utility connected sites with loads ranging from 200 to 1200 watts. The cost of energy for a remote power system is a function of the installed cost, the annual operating and maintenance costs, and the load. For SWECS, the wind resource at the site determines the maximum annual energy available and, as such, the size of the unit or number of units and the battery storage needed to meet the load requirements.

For cost comparison of power sources, a 400-watt load was selected as representative of a telecommunications site (Table 2). The site was assumed to be reasonably remote; that is, too far from utility power for economical hook-up. Installation costs include materials, delivery, concrete pads, labor and the items specifically required for one power source but not others; such as, fuel storage facilities and related site development costs or the cost of the large support structure required for solar cell arrays.

From Table 2, the cost per kwh (kilowatt hour) indicates significantly reduced energy costs: $0.88 per kwh for the HR2 against $2.20 per kwh for diesel and $2.16 per kwh for solar cells. The cost savings alone appear to justify application of a SWECS-based power system to reduce fuel consumption or reduce solar cell array and battery size. A wind power system at a television repeater site in Montana, for example, has displaced TEG (thermoelectric generator) supplied power for the last 18 months, saving more than $4500 in fuel costs alone ($1.00 per gallon).

Wind power today, within the remote power market, is at the threshold of acceptance. The perception of SWECS as a new, untested energy resource will change rapidly as more successful systems are installed.

Given the current deteriorating world energy situation and the expanding communications market, investment in SWECS will increasingly be made less for testing and demonstration purposes than for serious energy conservation and cost saving goals.

Hybrid systems such as the MCI installation at Kenna are quick, low risk methods of gaining experience with small wind energy conversion systems.

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